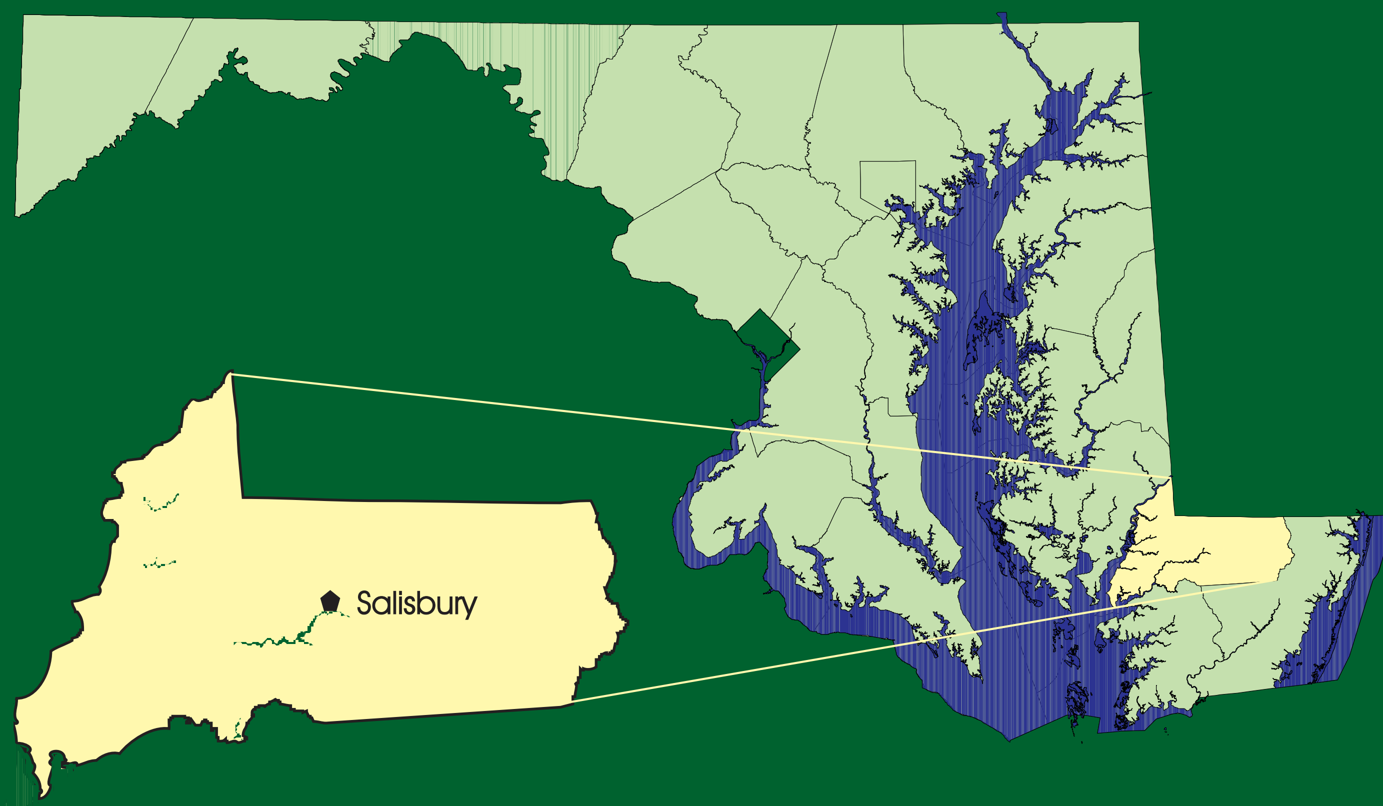
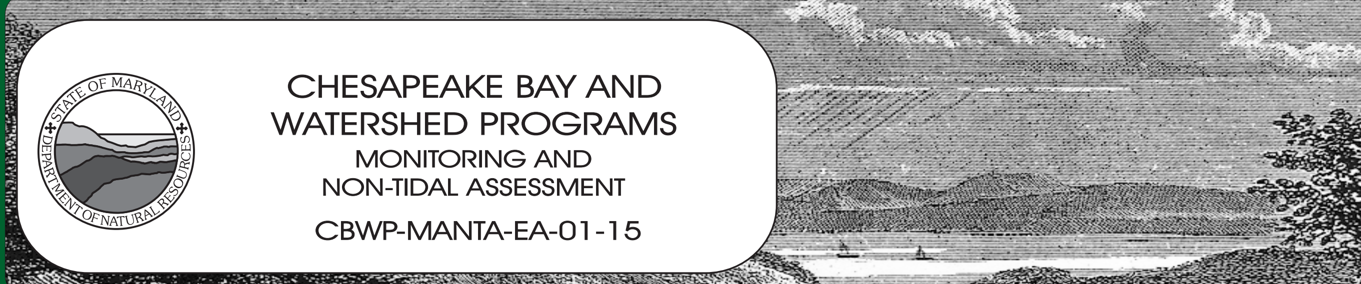
WICOMICO COUNTY

RESULTS OF THE 1994-1997 MARYLAND BIOLOGICAL STREAM SURVEY: COUNTY ASSESSMENTS





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WICOMICO COUNTY

Results of the 1994-1997 Maryland Biological Stream Survey: County-Level Assessments

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December 2001

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FOREWORD

This report is based on results of the Maryland Biological Stream Survey (MBSS), a program funded primarily by the Power Plant Research Program and administered by the Maryland Department of Natural Resources. Field data for the MBSS were collected by the Maryland Department of Natural Resources. Analyses of water chemistry samples were conducted by the University of Maryland's Appalachian Laboratory (AL) under Contract No. MA96-002-003. Much of the initial data analysis was conducted by Versar, Inc. under Contract No. PR-96-055-001\PRFP44 to MDNR's Power Plant Assessment Division.

This report helps fulfill two outcomes in MDNR's Strategic Plan: 1) A Vital and Life Sustaining Chesapeake Bay and Its Tributaries, and 2) Sustainable Populations of Living Resources and Healthy Ecosystems.

ACKNOWLEDGMENTS

We are grateful to Matt Kline, Dave Neely, Mick Burkett, Kelly Surgent, Rod McLeod, Melanie Pacella, and Shelaine Curd for their work in the field. We are also grateful to Katie Meagher of AL for long hours and weekends spent in the laboratory to ensure that holding times and quality control measures were met for water samples. We thank Janis Chaillou and the Versar landowner permission crew for ensuring that permissions to sample streams on private property were obtained in a timely fashion. We also thank MDNR's Marty Hurd for providing Geographic Information Systems (GIS) support. We are also grateful to Ron Klauda and John McCoy of MDNR, Michele Dobson of the Harford County Department of Public Works, and Phyllis Kilby of the Cecil County Government for editing; and Lamar Platt and Dung Nguyen for cover design.

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Table of Contents

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INTRODUCTION

This report presents county-level data from the 1994-1997 Maryland Biological Stream Survey (MBSS or the Survey). Previous reports have documented interim results from the 1995 (Roth et al. 1997) and 1996 (Roth et al. 1998a) sample years. In addition, a comprehensive final report was produced to assess the "state of the streams" throughout the state (Roth et al. 1999). All previous MBSS reports have presented information by individual drainage basins. Because there is a recognized need for stream health information at the county level, a series of reports were prepared; this report is part of that series. This introductory section recounts the origin of the Survey and describes its components.

Origin of the MBSS

More than 10 years ago, the Maryland Department of Natural Resources (MDNR) recognized that atmospheric deposition was one of the most important environmental problems resulting from the generation of electric power. To determine the extent of acidification of Maryland streams resulting from acidic deposition, MDNR conducted the Maryland Synoptic Stream Chemistry Survey (MSSCS) in 1987. The MSSCS estimated the number and extent of streams at that time affected by or sensitive to acidification statewide and demonstrated the potential for adverse effects on biota from acidification. However, little direct information was available on the biological responses of Maryland streams to water chemistry conditions. Data that were available could not be used (because of methodological differences and spatial coverage limitations) to compare conditions across regions or watersheds (Tornatore et al. 1992). Neither was it possible to assess the interactions between acidic deposition and other anthropogenic and natural influences (CBRM 1989). For these reasons, in 1993, MDNR created the MBSS to provide comprehensive information on the status of biological resources in Maryland streams and how they are affected by acidic deposition and other cumulative effects of anthropogenic stresses.

Description of the MBSS

The MBSS is intended to help environmental decision-makers protect and restore the natural resources of Maryland. The primary objectives of the MBSS are:

- to assess the current status of biological resources in Maryland's non-tidal streams;
- to quantify the extent to which acidic deposition has affected or may be affecting biological resources in the state;
- to examine which other water chemistry, physical habitat, and land use factors are important in explaining the current status of biological resources in streams;
- to compile the first statewide inventory of stream biota;
- to establish a benchmark for long-term monitoring of trends in these biological resources; and
- to target future local-scale assessments and mitigation measures needed to restore degraded biological resources.

In creating the Survey, MDNR implemented a probability-based sampling design as a cost-effective way to characterize statewide stream resources. By randomly selecting sites, the Survey can make quantitative inferences about the characteristics of all 9,258 miles of first-to-third-order, non-tidal streams in Maryland (based on stream length on a 1:250,000-scale base map). MDNR recognized that the utility of these estimates depended on accurately measuring appropriate attributes of streams. The Survey focuses on biology for two reasons: (1) organisms themselves have direct societal value and (2) biological communities integrate stresses over time and are a valuable and cost-effective means of assessing ecological integrity (i.e., the capacity of a resource to sustain its inherent potential).

Fish are an important component of stream integrity and one that also contributes to substantial recreational values. For these reasons, fish communities are a primary focus of the Survey. The Survey collects quantitative data for the calculation of population estimates for individual fish species (both game and nongame). These data can also be used to evaluate fish community composition, individual fish health, and the geographic distribution of commercially important, rare, or non-indigenous fish species. Benthic (bottom-dwelling) macroinvertebrates are another essential component of streams and they constitute the second principal focus of the Survey. The Survey uses rapid bioassessment procedures for collecting benthic macroinvertebrates; these semi-quantitative methods permit comparisons of relative abundance and community composition, and have proven to be an effective way of assessing biological integrity in streams (Hilsenhoff 1987, Lenat 1988, Plafkin et al. 1989, Kerans and Karr 1994, Resh 1995). The Survey also records the presence of reptiles and amphibians (herpetofauna), freshwater mussels, and aquatic plants (both submerged aquatic vegetation (SAV) and emergent macrophytes). The Survey has established rigorous protocols (Kazyak 1996) for each of these sampling components, as well as training and auditing procedures to assure that data quality objectives are met.

Although the MBSS sampling design and protocols provide exceptional information for characterizing the stream resources in Maryland, designation of degraded areas and identification of likely stresses requires additional activities. Assessing the condition of biological resources (whether they are degraded or not degraded) requires the development of ecological indicators that permit the comparison of sampled segment results to minimally impacted reference conditions (i.e., the biological community expected in watersheds with little or no human-induced impacts). The Survey has used its growing database of information collected with consistent methods and broad coverage across the state to develop and test indicators of individual biological components (Stribling et al. 1998, Roth et al. 1998b) and physical habitat quality (Hall et al. 1999). Each of these indicators consists of multiple metrics using the general approach developed for the Index of Biotic Integrity (IBI) (Karr et al. 1986, Karr 1991) and the Chesapeake Bay Benthic Restoration Goals (Ranasinghe et al. 1994). The fish and benthic macroinvertebrate IBIs (which combine attributes of both the number and the type of species found) are widely accepted indicators that have been adapted for use in a variety of geographic locations (Miller et al. 1988, Cairns and Pratt 1993, Simon 1999). The Survey is investigating the possibility of developing additional indicators (e.g., amphibians in small streams with few or no fish) and combining components into a composite indicator of biological integrity.

In addition to developing reference-based indicators, the Survey is applying a variety of analytical methods to the question of which stressors are most closely associated with degraded streams. This involves correlational and multivariate analyses of water chemistry, physical habitat, land use, and biological information (e.g., presence of non-native species). The biological information also provides a valuable opportunity for documenting aquatic biodiversity across the state; the distribution and abundance of species previously designated as rare only by anecdotal evidence can be determined, and unique combinations of species at the ecosystem and landscape levels can be identified. Land use and other landscape-scale metrics will play an important role in identifying the relative contributions of different stressors to the cumulative impact on stream resources. Ultimately, the Survey seeks to provide an integrated assessment of the problems facing Maryland streams that will facilitate interdisciplinary solutions for their restoration. The survey also provides resource managers with the locations of relatively undisturbed streams and watersheds that deserve protection.

METHODS

This section presents the specific study design and procedures used to implement the Maryland Biological Stream Survey. The study area of concern and the sampling design developed to characterize it are presented, along with field and laboratory methods for each component: fish, benthic macroinvertebrates, reptiles and amphibians, physical habitat, and water chemistry. Methods for aquatic vegetation and mussel sampling are presented, but the resulting data are not included in this report. A full description of MBSS methods can be found in Kazyak (1996).

MBSS Study Design

The Survey study area comprises 17 distinct drainage basins across the state. Random sampling was used to allow the estimation of unbiased summary statistics (e.g., means, proportions, and their respective variances) for the entire state, a particular basin, and subpopulations of interest (e.g., streams with pH < 5).

Because it would have been cost prohibitive to visit a sufficient number of sites in all basins in a single year, lattice sampling was used to schedule sampling of all basins over a three-year period, 1995-1997. Lattice sampling, also known as multistratification, is a cost-effective means of allocating effort across time in a large geographic area (Heimbuch 1999, Jessen 1978, Cochran 1977). A table, or lattice, was formed by arranging 17 basins in 17 rows, and the years in 3 columns. Lattice sampling was the method used for selecting cells from this 17x3 table so that all basins would be sampled over a three-year period and all basins would have a non-zero probability of being sampled in a given year. The data presented in this report include those collected at random sampling sites within the 17 principal basins in Maryland, as well as sites from the 1994 demonstration project. Because no estimates were calculated for this report, these data were included to supplement the number of sites.

The sampling frame for the Survey was constructed by overlaying basin boundaries on a map of all blue-line stream reaches in the study area as digitized on a U.S. Geological Survey 1:250,000 scale topographic map. This sample frame was similar to that used by the earlier Maryland Synoptic Stream Chemistry Survey (MSSCS) conducted in 1987 (Knapp and Saunders 1987, Knapp et al. 1988). The Strahler convention (Strahler 1957) was used for ranking stream reaches by order; first-order reaches, for example, are the most upstream reaches in the branching stream system. Sampling was restricted to non-tidal, third-order and smaller stream reaches, excluding impoundments that were non-wadable or that substantially altered the riverine nature of the reach (Kazyak 1994). Together, these first-through third-order streams comprise about 90% of all stream and river miles in Maryland. Stream reaches were further divided into non-overlapping, 75-meter segments; these segments were the elementary sampling units from which biological, water chemistry, and physical habitat data were collected.

The 1995-1997 MBSS study design was based on stratified random sampling of segments within each basin; each basin was stratified by stream order. Within a stream order, the number of segments sampled per basin is proportional to the number of stream miles in the basin. To achieve the target number of samples per stream order within each basin, a given number of segments were randomly selected from each basin and ranked in order of selection. In all basins, extra segments were selected as a contingency against loss of sampling sites from restricted access to selected streams or from streams that were dry, too deep, or otherwise unsampleable owing to field conditions. In some basins, where only a small number of sites would have been selected using this method, additional random sites were selected to increase sample size. These extra sites (selected at random using the method described above) were used to provide better basinwide estimates; they were not included in the estimates of statewide conditions.

Permissions were obtained to access privately owned land adjacent to or near each stream segment. The procedures for obtaining permissions are described in Chaillou (1995). Because landowner permissions were obtained in a synoptic fashion and some variation in these rates occurred, we obtained more permissions than were needed for the Survey. Only the highest ranking sites were sampled until the target goal for that basin was reached. For the three year study, the success rate for obtaining permission to access stream sampling segments was high. Eighty-eight percent of sites that were targeted for permission were sampled.

Reasons for permission denial varied and generally reflected the preferences of landowners regarding property access, rather than any specific types of land. In rare cases, permission denial may affect the interpretation of Survey estimates, but only where denials occur in streams with characteristics that differ from the general population of streams. In one example of potential bias, several sites with known coal mining activities in the North Branch Potomac basin denied permission to sample, likely under representing the proportion of acid mine drainage streams in the population.

Field and Laboratory Methods

Benthic macroinvertebrate and water quality sampling were conducted in spring, when the benthos are thought to be reliable indicators of environmental stress (Plafkin et al. 1989) and when acid deposition effects are often the most pronounced. Fish, reptiles and amphibians, aquatic vegetation, and mussel sampling, along with physical habitat evaluations, were conducted during the low-flow period in summer. Fish community composition tends to be stable during summer, and low flow is advantageous for electrofishing. Because low-flow conditions in summer may be a primary factor limiting the abundance and distribution of fish populations, habitat assessments were performed during the summer. The sample size in summer is lower than in spring because some streams were dry in summer or were, in rare cases, otherwise unsampleable.

To reduce temporal variability, sampling during spring and summer was conducted within specific, relatively narrow time intervals, referred to as index periods (Janicki et al. 1993). These index periods were defined by degree-day limits for specific parts of the state. This approach provided a synoptic assessment of the current status of stream biota, water quality, and physical habitat in the 17 basins sampled. The spring index period was the time period between approximately March 1 and May 1, with end of the index period determined by degree-day accumulation as specified in Hilsenhoff (1987). In reality, most spring samples (78%) were collected in March, well before degree-day accumulation limits were approached. The summer index period was between June 1 and September 30 (Kazyak 1994).

Data Collection and Measurement

Field sampling followed procedures specified in the MBSS sampling manual (e.g., Kazyak 1996). A summary of the variables measured and the field and laboratory methods used to conduct the sampling follows.

Fish

Fish were sampled during the summer index period using double-pass electrofishing within 75-meter stream segments. Block nets were placed at each end of the segment and direct current backpack electrofishing units were used to sample the entire segment. An attempt was made to thoroughly fish each segment, and consistent effort was applied over the two passes. This sampling approach allowed calculation of several metrics useful in calculating a biological index and produced unbiased estimates of fish species abundance.

In small streams, a single electrofishing unit was used. In larger streams, two to five units were employed to effectively sample the site. Captured fish were identified to species, counted, weighed, and released. Any individuals that could not be identified to species were retained for laboratory confirmation. For each pass, all individuals of each gamefish species (defined as trout, bass, walleye, pike, chain pickerel, and striped bass) were measured for total length and examined for visible external pathologies or anomalies. For nongame species, up to 100 fish of each species (from both passes) were examined for visible external pathologies or anomalies. For each pass, all non-game species were weighed together for an aggregate biomass measurement; gamefish were also weighed in aggregate to the nearest 10 g.

Electrofishing was also conducted at supplemental, non-randomly selected sites during the summer index period. The presence of each species of fish was recorded for these segments to provide additional qualitative information on statewide fish distributions. Sampling effort at most qualitative sites was based on doubling the elapsed time since the last species was recorded or a minimum of 600 seconds of electrofishing effort.

After processing the fish collected in the field, voucher specimens were retained for each species not previously collected in the drainage basin. In addition, all individuals which could not be positively identified in the field were retained. The remaining fish were released. All voucher specimens and fish retained for positive identification in the laboratory were examined and verified by the MBSS Quality Assurance Officer or ichthyologists at Frostburg State University, Frostburg, Maryland or the Smithsonian Institution, Washington, DC.

Benthic Macroinvertebrates

Benthic macroinvertebrates were collected to provide a qualitative description of the community composition at each sampling site (Kazyak 1996). Sampling was conducted during the spring index period. Benthic community data were collected for the purpose of calculating biological metrics, such as those described in EPA's Rapid Bioassessment Protocols (Plafkin et al. 1989), and use as an indicator of biological integrity for Maryland streams.

At each segment, a 600 micron mesh "D" net was used to collect organisms from habitats likely to support the greatest taxonomic diversity. A riffle area was preferred, but other habitats were also sampled using a variety of techniques including kicking, jabbing, and gently rubbing hard surfaces by hand to dislodge organisms. If available, other habitat types were sampled, including rootwads, woody debris, leaf packs, macrophytes, and undercut banks. Each jab covered one square foot, and a total of approximately 2.0 m^2 (20 square feet) of combined substrates was sampled and preserved in 70% ethanol. In the laboratory, the preserved sample was transferred to a gridded pan and organisms were picked from randomly selected grid cells until the cell that contained the 100th individual (if possible) was completely picked. Some samples had fewer than 100 individuals. The benthic macroinvertebrates were identified to genus, or lowest practicable taxon, in the laboratory.

Index of Biotic Integrity

Sites were evaluated using both the fish (F-IBI) and benthic macroinvertebrate (B-IBI) IBIs developed for the MBSS (for detailed methods, see Roth et al. 1997 and Stribling et al. 1998). IBI scores for the MBSS are determined by comparing the fish or benthic macroinvertebrate assemblages at each site to those found at minimally impacted reference sites. Three separate formulations were employed for the fish IBI, one for each of three distinct geographic areas: Coastal Plain, Eastern Piedmont, and Highland. The two formulations used for the benthic IBI cover the Coastal Plain and non-Coastal Plain regions. Individual metrics for the IBI are scored 1, 3, or 5, based on comparison with the distribution of metric values at reference sites. For either the individual metrics or total IBI, a score of 3 or greater is considered comparable to reference site conditions, while scores falling below this threshold differ significantly from the reference conditions. Scores for the MBSS IBIs are calculated as the mean of the individual metric scores and therefore range from 1 to 5. Some other programs have used a similar approach (e.g., Weisberg et al. 1997), while others have instead computed the IBI as the total of individual metric scores. For example, Karr et al. (1986) calculated IBI as the sum of 12 metric scores, with totals ranging from 12 to 60 points.

Reptiles and Amphibians

At each sample segment, reptiles and amphibians were identified and the presence of observed species was recorded during the summer index period. A search of the riparian area was conducted within 5 meters of the stream on both sides of the 75-meter segment. Any reptiles and amphibians collected during the electrofishing of the stream segment were also included in the species list. Individuals were identified to species when possible. Voucher specimens and individuals not positively identifiable in the field were retained for examination in the laboratory and confirmation by herpetologists at the Smithsonian Institution, Washington, DC, or Towson University, Towson, Maryland.

Physical Habitat

Habitat assessments were conducted at all stream segments as a means of assessing the importance of physical habitat to the biological integrity and fishability of freshwater streams in Maryland. Procedures for habitat assessments (Kazyak 1996) were derived from two currently used methodologies: EPA's Rapid

Bioassessment Protocols (RBPs) (Plafkin et al. 1989), as modified by Barbour and Stribling (1991), and the Ohio EPA's Qualitative Habitat Evaluation Index (QHEI) (Ohio EPA 1987, Rankin 1989). A number of characteristics (instream habitat, epifaunal substrate, velocity/depth diversity, pool/glide/eddy quality, riffle/run quality, channel alteration, bank stability, embeddedness, channel flow status, and shading) were assessed qualitatively, based on visual observations within each 75-meter sample segment. Riparian zone vegetation width was estimated to the nearest meter, up to 50 meters from the stream. Additional observations of the surrounding area were used to assign ratings for aesthetic value (based on visible signs of human refuse at a site) and remoteness (based on distance from the nearest road, accessibility, and evidence of human activity). Also recorded were the presence or absence of various stream features including substrate types, various morphological characteristics, beaver ponds, point sources, and stream channelization. Local land uses visible from the stream segment and riparian vegetation type were also noted. Several additional physical characteristics were measured quantitatively to further characterize the habitat for each segment (see Kazyak 1996 for details). Quantitative measurements of the segment included maximum depth, stream gradient, velocity, thalweg depth, number of functional rootwads, number of functional large woody debris, wetted width, sinuosity, and overbank flood height. A velocity/depth profile was measured or other data were collected to enable calculation of discharge.

Physical Habitat Index

The Physical Habitat Index (PHI) was developed using MBSS data from 1994 to 1997 (Hall et al. 1999). As was the case in development of the fish and benthic IBIs, the conceptual approach was based on evaluating the relative importance (discriminatory power) of individual metrics and combinations of metrics explaining natural differences in streams throughout Maryland. These metrics were derived from both quantitative and qualitative habitat data collected during the summer index period. Based on analyses conducted for both fish IBI (Roth et al. 1998) and benthic macroinvertebrate IBI (Stribling et al. 1998) development in Maryland, the State was divided into two regions: the Coastal Plain and non-Coastal Plain. The resulting index was then adjusted to a centile scale that rated each sample segment as follows: Good - 72 to 100; Fair - 42 to 71.9; Poor - 12 to 41.9; and Very Poor - 0 to 11.9.

Water Chemistry

During the spring index period, water samples were collected at each site for analysis of pH, acid neutralizing capacity (ANC), conductivity, sulfate, nitrate-nitrogen, and dissolved organic carbon (DOC). These variables describe basic water quality conditions with an emphasis on factors related to acidic deposition.

Grab samples were collected in one-liter bottles for analysis of all analytes except pH. Water samples for pH were collected with 60 ml syringes, which allowed purging of air bubbles to minimize changes in carbon dioxide content (EPA 1987). Samples were stored on wet ice and shipped on wet ice to the analytical laboratory within 48 hours. Laboratory analyses were carried out by the University of Maryland's Appalachian Laboratory in Frostburg.

Chemical analysis of water samples followed standard methods described in EPA's Handbook of Methods for Acid Deposition Studies (EPA 1987). EPA protocols were followed, except that ANC sample volume was reduced to 40 ml to ease handling. Routine daily quality control (QC) checks included processing duplicate, blank, and calibration samples according to EPA guidelines for each analyte. Field duplicates were taken at 5% of all sites. Routine QC checks helped to identify and correct errors in sampling routines or instrumentation at the earliest possible stage.

During the summer index period, in situ measurements of dissolved oxygen (DO), pH, temperature, and conductivity were collected at each site to further characterize existing water quality conditions that might influence biological communities. Measurements were made at an undisturbed section of the segment, usually in the middle of the stream channel, using electrode probes. Instruments were calibrated daily and calibration logbooks were maintained to document instrument performance.

Recognizing that water temperature is an important factor affecting stream condition, but one that varies daily and seasonally, temperature loggers were deployed at 220 sites in five basins during 1997. The basins sampled were: the Choptank, Susquehanna, Potomac Washington Metro, Patuxent, and Pocomoke. Onset Computer Corporation Optic Stowaway temperature loggers were anchored in each site during the summer index period. Water temperature was recorded every 15 minutes from June 15 until mid-September.

Mussels

During the summer index period, freshwater mussels were sampled qualitatively by examining each 75-meter stream segment for their presence. Mussels were identified to species, their presence recorded, and subsequently released. Species not positively identifiable in the field were retained for confirmation by U.S. Geological Survey (USGS) Biological Resources Division staff.

Aquatic Vegetation

Aquatic vegetation was sampled qualitatively by examining each 75-meter segment for the presence of aquatic plants. Plants were identified to species and their presence recorded for each site. While the primary objective was to document the presence of submerged aquatic vegetation (SAV), emergent and floating aquatic vegetation was also recorded when encountered. Species not positively identifiable in the field were retained for laboratory examination and confirmation by MDNR's staff expert on SAV. Due to the difficulty in long-term preservation, no permanent vouchers of aquatic vegetation were retained.

Data Management

All crews used standardized pre-printed data forms developed for the Survey to ensure that all data for each sampling segment were recorded and standard units of measure were used (Kazyak 1996). Using standard data forms facilitated data entry and minimized transcription error. The field crew leader and a second reviewer checked all data sheets for completeness and legibility before leaving each sampling location. Original data sheets were sent to the Data Management Officer for further review and data entry, while copies were retained by the field crews.

A custom database application, in which the input module was designed to match each of the field data sheets, was used for data entry. Data were independently entered into two databases and compared using a computer program as a quality-control procedure. Differences between the two databases were resolved from original data sheets or through discussions with field crew leaders.

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Maryland Biological Stream Survey Data

COUNTY SUMMARY

A total of 48 quantitative sites were sampled in Wicomico County by MBSS sampling crews during 1994-1997 (Table 1; Figure 2). Qualitative fish sampling was conducted at an additional 12 sites to provide a more complete picture of fish species distributions. Appendix A provides a summary of the types of data available for each of the sites sampled.

Species Highlights

Twenty-seven fish species were collected (Table 2). This number ties for a ranking of nineteenth in the state. The most commonly found fish species were eastern mudminnow, pirate perch, and American eel. Swamp darter and banded sunfish, two rare fish species, were collected. Both of these species are currently being considered for listing as threatened or endangered in Maryland.

The 117 genera of benthic macroinvertebrates found in the county ranks eleventh among Maryland counties for benthos (Table 3). Sixty-seven genera, or 57% of the taxa found, were collected at a single site. Only 3 genera were found at more than half of the sites sampled.

Thirteen species of reptiles and amphibians were found in or near Wicomico County streams (Table 4), ranking the county seventeenth in the state. No state or federally listed reptiles or amphibians were collected during the sampling.

Ecological Health

Based on the indicators currently in use by the MBSS, the overall ecological health of Wicomico County's headwater streams can best be described as Fair to Poor. The average F-IBI score was 3.26 (low end of the Fair range, ranking thirteenth among counties in the state) and the average B-IBI score among sites was 2.5 (middle of the Poor category, ranking fifteenth among counties in the state). Based on F-IBI and B-IBI scores from individual sites, the highest rated streams in the county are Barren Creek and Adkin's Race (Table 6). The worst rated streams include Truitt Branch, Campbell Ditch, and an unnamed tributary to the Nanticoke River. It should be noted that a modified IBI for fish in acidic, blackwater streams is being developed, and that F-IBI scores could presumably improve when the blackwater IBI is applied to streams in Wicomico County.

Other noteworthy points include a ranking of third lowest in the state for pH (the mean value for sites sampled was 6.17), a tie for fifteenth in the ranking of trash found along streams, and a ranking of twentieth for dissolved oxygen (DO). The low ranking for DO is likely due to a combination of increased Biochemical Oxygen Demand (BOD) from agriculture and the naturally low re-aeration in low gradient systems.

Physical Habitat

Physical habitat in Wicomico County was rated as Fair by the Physical Habitat Index. Values ranged from 1.27 to 87.75, with an average score of 44.55 (low end of the Fair range, ranking eighteenth among counties in the state) (Table 6; Figure 5). Another point of interest is a ranking of twentieth for the amount of stream shading.

Nitrate-Nitrogen

Nitrate-nitrogen values at sites sampled averaged 3.1 mg/L, or seventh worst in the state. The streams with the lowest nitrate values were Campbell Ditch and an unnamed tributary to the Nanticoke River, while the streams with the highest nitrate values were Owen's Branch and Truitt Branch (Table 7). In no stream was the EPA limit for drinking water (10 mg/L) exceeded.

Table 1. Site information and land use data collected at Maryland Biological Stream Survey sites in Wicomico County, 1994-1997. Basin abbreviations are as follows: NW - Nanticoke-Wicomico Rivers; PC - Pocomoke River.

Site	Latitude	Longitude	Stream Name	Basin	Order	Catchment Acres	% Urban	% Agric.	% Forest
SO-S-005-109-95	38.2978	75.6621	Passerdyke Creek	NW	1	4870.35	1.37	40.09	51.55
WI-S-005-1-94	38.3442	75.3723	Truitt Br	PC	2	1489.00	0.02	54.03	36.24
WI-S-005-4-94	38.3397	75.3804	Truitt Br	PC	2	1681.80	0.02	54.99	35.44
WI-S-016-211-95	38.3599	75.5784	South Prong Wicomico R	NW	2	13550.87	9.17	44.55	38.90
WI-S-017-119-95	38.3432	75.5216	Walston Branch	NW	1	999.92	19.99	30.54	23.40
WI-S-019-208-97	38.4310	75.3750	South Fork Green Run	PC	2	4168.44	0.01	71.93	26.60
WI-S-019-217-97	38.4260	75.3660	Green Run	PC	2	4572.27	0.04	71.51	26.36
WI-S-023-112-95	38.5118	75.7334	Ut Nanticoke R	NW	1	2072.47	2.71	48.87	42.82
WI-S-034-201-95	38.4600	75.7058	Barren Creek	NW	2	6172.31	0.36	69.40	27.07
WI-S-037-210-97	38.3970	75.3420	Burnt Mill Br	PC	2	11721.44	4.17	55.74	33.62
WI-S-041-202-97	38.3900	75.4780	Perdue Cr	PC	2	107.24	42.50	43.13	12.45
WI-S-041-214-97	38.3540	75.4560	Forest Grove Br	PC	2	1570.80	1.41	50.97	40.57
WI-S-054-1-94	38.4026	75.3761	Burnt Mill Br	PC	2	8269.80	4.92	48.80	40.62
WI-S-054-2-94	38.4038	75.3781	Burnt Mill Br	PC	2	8242.40	4.93	48.77	40.62
WI-S-055-303-97	38.3310	75.3260	Pocomoke R	PC	3	71830.65	1.41	50.37	29.24
WI-S-057-1-94	38.3241	75.3585	Adkins Race	PC	3	13653.90	1.75	43.30	43.76
WI-S-057-309-97	38.3260	75.3620	Adkins Race	PC	3	13524.60	1.76	43.11	44.02
WI-S-057-311-97	38.3220	75.3570	Adkins Race	PC	3	13717.26	1.74	43.48	43.60
WI-S-057-319-97	38.3250	75.3600	Adkins Race	PC	3	13580.98	1.76	43.14	43.96
WI-S-057-3-94	38.3266	75.3624	Adkins Race	PC	3	13490.60	1.77	43.11	44.02
WI-S-059-106-97	38.3510	75.3670	Truitt Br	PC	1	1245.28	0.03	51.46	37.07
WI-S-059-1-94	38.3524	75.3645	Truitt Br	PC	1	1222.50	0.02	51.27	37.23
WI-S-059-2-94	38.3552	75.3609	Truitt Br	PC	1	797.80	0.04	47.31	37.63
WI-S-060-2-94	38.3554	75.3737	Truitt Br	PC	1	519.50	0.00	71.28	16.43
WI-S-060-3-94	38.3581	75.3732	Truitt Br	PC	1	444.00	0.00	75.08	14.00
WI-S-061-104-97	38.4300	75.4420	Burnt Mill Br	PC	1	494.54	0.00	62.31	35.75
WI-S-063-220-95	38.4206	75.5819	Leonard Pond Run	NW	2	10170.87	8.08	34.23	53.87
WI-S-067-207-97	38.4020	75.3700	Burnt Mill Br	PC	2	9189.98	4.47	52.18	37.96
WI-S-067-219-97	38.4020	75.3580	Burnt Mill Br	PC	2	10352.87	3.99	54.67	35.77
WI-S-073-114-95	38.3817	75.6194	Owens Branch	NW	1	1054.80	8.62	55.50	35.37
WI-S-074-103-97	38.4020	75.3500	Murray Br	PC	1	694.16	0.00	68.43	21.00
WI-S-075-206-95	38.4216	75.5738	Leonard Pond Run	NW	2	8376.22	3.02	32.35	60.40
WI-S-082-113-95	38.4122	75.5980	Little Burnt Branch	NW	1	1871.47	0.05	67.83	30.89
WI-S-084-107-97	38.3800	75.4260	Campbell Ditch	PC	1	1444.27	5.26	49.44	40.56
WI-S-085-102-95	38.4312	75.7838	Ut Nanticoke R	NW	1	470.73	0.07	42.62	42.84
WI-S-999-114-97	38.3030	75.3700	Duncan Ditch	PC	1	1912.07	0.09	51.42	43.95
WO-S-003-306-97	38.4060	75.3180	Pocomoke R	PC	3	35623.21	0.20	51.11	24.17
WO-S-003-308-97	38.4020	75.3180	Pocomoke R	PC	3	35917.29	0.20	50.99	24.28
WO-S-003-312-97	38.4200	75.3250	Pocomoke R	PC	3	33344.47	0.21	51.17	23.65
WO-S-003-314-97	38.3830	75.3290	Pocomoke R	PC	3	36818.00	0.28	50.72	24.21
WO-S-003-320-97	38.4110	75.3200	Pocomoke R	PC	3	34176.61	0.20	51.07	23.81
WO-S-005-315-97	38.3730	75.3240	Pocomoke R	PC	3	50907.64	1.47	52.07	26.35
WO-S-008-1-94	38.4351	75.3356	Pocomoke R	PC	3	22964.80	0.28	45.44	21.47
WO-S-008-305-97	38.4300	75.3340	Pocomoke R	PC	3	32103.65	0.21	51.42	23.34
WO-S-008-3-94	38.4371	75.3362	Pocomoke R	PC	3	22921.00	0.29	45.49	21.50
WO-S-019-318-97	38.4250	75.3320	Pocomoke R	PC	3	32338.57	0.21	51.34	23.26
WO-S-061-205-97	38.4300	75.3340	North Fork Green Run	PC	2	8933.33	0.03	67.15	28.03
WO-S-061-206-97	38.4370	75.3500	North Fork Green Run	PC	2	8137.92	0.04	67.39	29.45

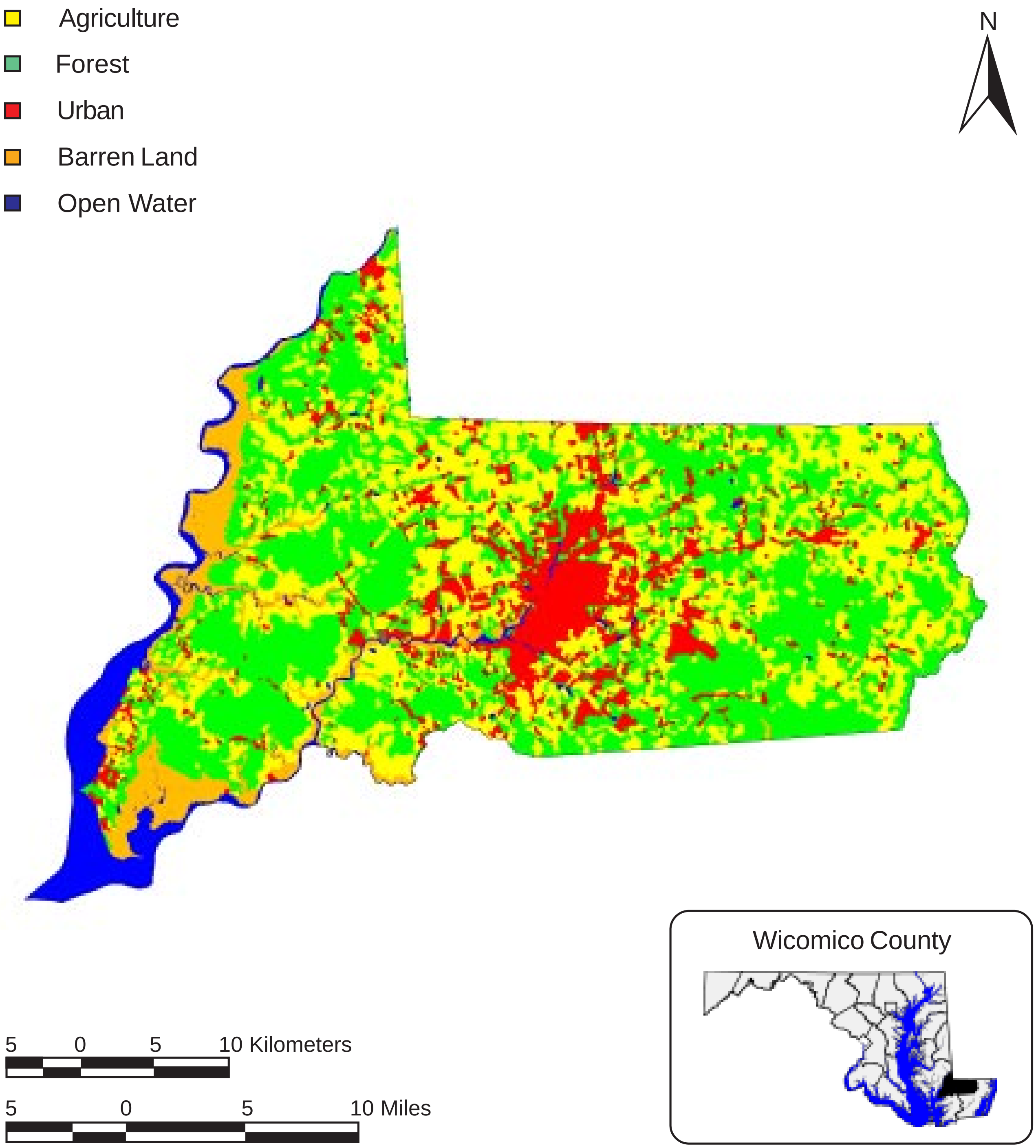

Figure 1. Land use in Wicomico County (MOP 1994).

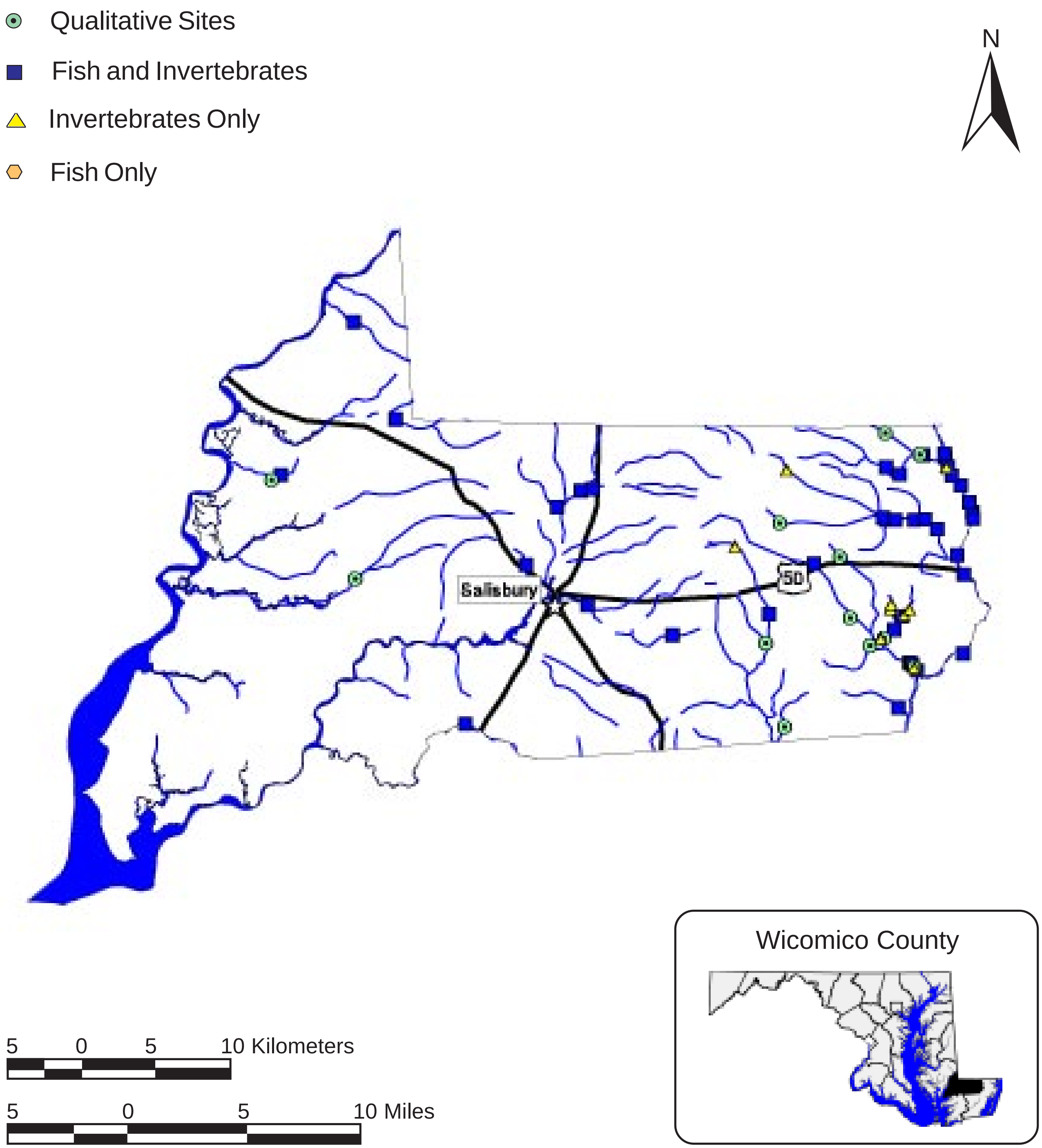

Figure 2. Location of Maryland Biological Stream Survey sites in Wicomico County, 1994-1997.

Table 2. Percent occurrence of fish species collected at Maryland Biological Stream Survey sites in Wicomico County, 1994-1997.

Family	Common Name	Scientific Name	Number of Occurrences	Percent Occurrence
Petromyzontidae	least brook lamprey	*Lampetra aepyptera*	17	43.59
Lepisosteidae	longnose gar	*Lepisosteus osseus*	1	2.56
Anguillidae	American eel	*Anguilla rostrata*	33	84.62
Cyprinidae	satinfin shiner	*Cyprinella analostana*	13	33.33
	eastern silvery minnow	*Hybognathus regius*	2	5.13
	golden shiner	*Notemigonus crysoleucas*	21	53.85
	spottail shiner [1]	*Notropis hudsonius*		
	swallowtail shiner	*Notropis procne*	6	15.38
Catostomidae	creek chubsucker	*Erimyzon oblongus*	24	61.54
Ictaluridae	white catfish	*Ameiurus catus*	3	7.69
	yellow bullhead	*Ameiurus natalis*	19	48.72
	brown bullhead	*Ameiurus nebulosus*	10	25.64
	channel catfish	*Ictalurus punctatus*	1	2.56
	tadpole madtom	*Noturus gyrinus*	26	66.67
	margined madtom	*Noturus insignis*	13	33.33
Esocidae	redfin pickerel	*Esox americanus vermiculatus*	30	76.92
	chain pickerel	*Esox niger*	7	17.95
Umbridae	eastern mudminnow	*Umbra pygmaea*	37	94.87
Aphredoderidae	pirate perch	*Aphredoderus sayanus*	31	79.49
Cyprinodontidae	banded killifish [1]	*Fundulus diaphanus*		
	mummichog	*Fundulus heteroclitus*	1	2.56
Poeciliidae	mosquitofish	*Gambusia affinis*	3	7.69
Percichthyidae	white perch	*Morone americana*	1	2.56
Centrarchidae	mud sunfish	*Acantharchus pomotis*	3	7.69
	bluespotted sunfish	*Enneacanthus gloriosus*	26	66.67
	banded sunfish	*Enneacanthus obesus*	20	51.28
	redbreast sunfish	*Lepomis auritus*	15	38.46
	pumpkinseed	*Lepomis gibbosus*	27	69.23
	bluegill	*Lepomis machrochirus*	23	58.97
	largemouth bass	*Micropterus salmoides*	11	28.21
	black crappie	*Pomoxis nigromaculatus*	2	5.13
Percidae	swamp darter	*Etheostoma fusiforme*	9	23.08
	tessellated darter	*Etheostoma olmstedi*	29	74.36
	glassy darter	*Etheostoma vitreum*	3	7.69
	yellow perch	*Perca flavescens*	11	28.21

[1] Qualitative Sites

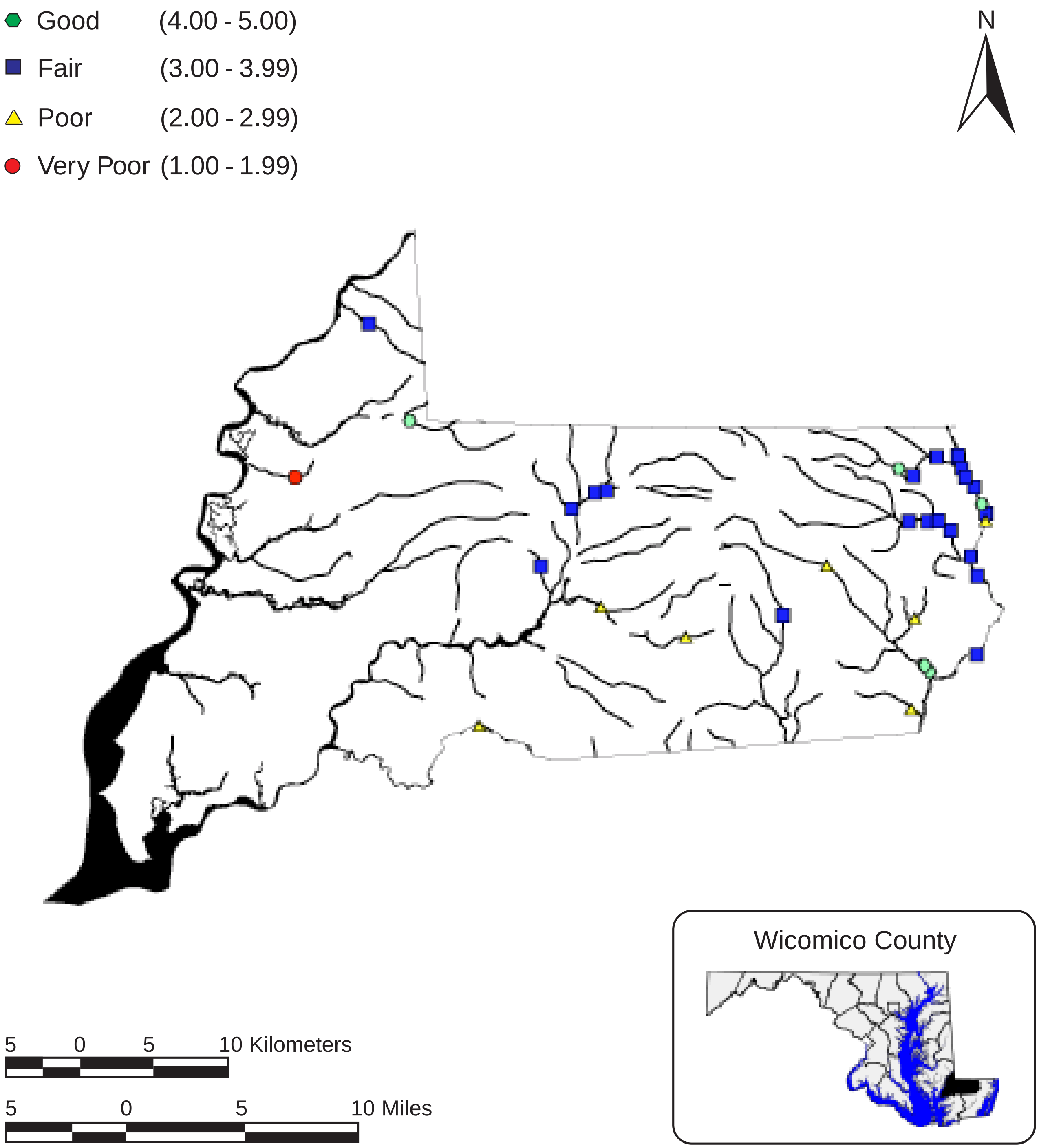

Figure 3. Stream ecological conditions based on the Fish Index of Biotic Integrity (F-IBI) at Maryland Biological Stream Survey sites in Wicomico County, 1994-1997.

Table 3. Tolerance Value (TV)[1], Functional Feeding Group (FFG), Habit, and Percent Occurrence of benthic macroinvertebrate taxa[2] collected at Maryland Biological Stream Survey sites in Wicomico County, 1994-1997. Abbreviations of habits are as follows: bu - burrower, cn - clinger, cb - climber, sp - sprawler, dv - diver, and sk - skater.

Class	Order	Family	Genus	TV	FFG	Habit	Percent Occurrence
Nematomorpha[3]						bu	2.70
Enopla	Hoplonemertea	Tetrastemmatidae	*Prostoma* Sp.		Predator		13.51
Turbellaria	Tricladida	Planariidae	*Dugesia* Sp.	7	Predator	sp	5.41
Oligochaeta	Lumbriculida	Lumbriculidae		10	Collector	bu	21.62
Oligochaeta	Tubificida	Enchytraeidae		10	Collector	bu	5.41
		Naididae		10	Collector	bu	10.81
		Tubificidae		10	Collector	cn	24.32
			Limnodrilus Sp.	10	Collector	cn	5.41
Hirudinea				8	Predator	sp	5.41
Gastropoda	Basommatophora	Lymnaeidae	*Pseudosuccinea* Sp.	6	Collector	cb	5.41
		Physidae	*Physella* Sp.	8	Scraper	cb	18.92
		Planorbidae	*Gyraulus* Sp.	8	Scraper	cb	2.70
			Menetus Sp.	8	Scraper	cb	5.41
Gastropoda	Mesogastropoda	Hydrobiidae	*Amnicola* Sp.	8	Scraper	cb	8.11
		Viviparidae	*Campeloma* Sp.	6	Scraper	cb	2.70
			Viviparus Sp.	1	Scraper	cb	5.41
Pelecypoda	Veneroida	Corbiculidae	*Corbicula* Sp.	6	Filterer	bu	2.70
		Sphaeriidae			Filterer	bu	8.11
			Pisidium Sp.	8	Filterer	bu	27.03
			Sphaerium Sp.	8	Filterer	bu	10.81
Copepoda				8	Collector		2.70
Ostracoda				8	Collector		2.70
Malacostraca	Amphipoda					sp	8.11
		Crangonyctidae		6	Collector	sp	2.70
			Crangonyx Sp.	4	Collector	sp	43.24
		Gammaridae	*Gammarus* Sp.	6	Shredder	sp	37.84
		Hyalellidae	*Hyalella* Sp.	6	Shredder	sp	2.70
Malacostraca	Decapoda	Cambaridae	*Cambarus* Sp.	6	Collector	sp	2.70
		Palaemonidae	*Palaemonetes* Sp.	7		sp	27.03
Malacostraca	Isopoda	Asellidae	*Caecidotea* Sp.	8	Collector	sp	59.46
Insecta	Ephemeroptera	Caenidae	*Caenis* Sp.	7	Collector	sp	10.81
		Ephemerellidae	*Eurylophella* Sp.	4	Scraper	cn, sp	5.41
		Heptageniidae	*Epeorus* Sp.	0	Scraper	cn	2.70
			Stenonema Sp.	4	Scraper	cn	43.24
		Leptophlebiidae	*Leptophlebia* Sp.	4	Collector	sw, cn, sp	2.70
			Paraleptophlebia Sp.	2	Collector	sw, cn, sp	5.41
Insecta	Odonata	Aeshnidae	*Boyeria* Sp.	2	Predator	cb, sp	2.70
		Calopterygidae	*Calopteryx* Sp.	6	Predator	cb	16.22
		Coenagrionidae			Predator	cb	8.11
			Argia Sp.	8	Predator	cn, cb, sp	2.70
			Enallagma Sp.	8	Predator	cb	5.41
		Corduliidae	*Somatochlora* Sp.	1	Predator	sp	2.70
		Gomphidae	*Gomphus* Sp.	5	Predator	bu	2.70
			Lanthus Sp.	6	Predator	bu	2.70
			Progomphus Sp.	5	Predator	bu	2.70
		Libellulidae	*Libellula* Sp.		Predator	sp	2.70
Insecta	Plecoptera	Nemouridae			Shredder	sp, cn	2.70

Table 3 (cont.). Tolerance Value (TV)[1], Functional Feeding Group (FFG), Habit, and Percent Occurrence of benthic macroinvertebrate taxa[2] collected at Maryland Biological Stream Survey sites in Wicomico County, 1994-1997. Abbreviations of habits are as follows: bu - burrower, cn - clinger, cb - climber, sp - sprawler, dv - diver, and sk - skater.

Class	Order	Family	Genus	TV	FFG	Habit	Percent Occurrence
			Amphinemura Sp.	3	Shredder	sp, cn	2.70
			Ostrocerca Sp.		Shredder	sp, cn	5.41
			Prostoia Sp.		Shredder	sp, cn	8.11
		Perlidae			Predator	cn	5.41
			Acroneuria Sp.	0	Predator	cn	2.70
		Perlodidae	*Isoperla* Sp.	2	Predator	cn, sp	2.70
		Taeniopterygidae	*Taeniopteryx* Sp.	2	Shredder	sp, cn	8.11
Insecta	Hemiptera	Belostomatidae	*Belostoma* Sp.	10	Predator	cb, sw	2.70
		Corixidae			Predator	sw	5.41
Insecta	Megaloptera	Corydalidae	*Chauliodes* Sp.	4	Predator	cn, cb	2.70
			Nigronia Sp.	0	Predator	cn, cb	5.41
Insecta	Trichoptera	Brachycentridae	*Brachycentrus* Sp.	1	Filterer	cn	5.41
		Calamoceratidae	*Heteroplectron* Sp.	3	Shredder	sp	2.70
		Dipseudopsidae	*Phylocentropus* Sp.	5	Collector	bu	2.70
		Hydropsychidae	*Cheumatopsyche* Sp.	5	Filterer	cn	29.73
			Hydropsyche Sp.	6	Filterer	cn	8.11
		Hydroptilidae	*Oxyethira* Sp.	3	Collector	cb	2.70
		Lepidostomatidae	*Lepidostoma* Sp.	3	Shredder	cb, sp, cn	5.41
		Leptoceridae	*Oecetis* Sp.	8	Predator	cn, sp, cb	16.22
			Triaenodes Sp.	6	Shredder	sw, cb	13.51
		Limnephilidae			Shredder	cb, sp, cn	10.81
			Ironoquia Sp.	3	Shredder	sp	21.62
			Limnephilus Sp.	3	Shredder	cb, sp, cn	2.70
			Pycnopsyche Sp.	4	Shredder	sp, cb, cn	24.32
		Philopotamidae	*Chimarra* Sp.	4	Filterer	cn	5.41
		Phryganeidae	*Ptilostomis* Sp.	5	Shredder	cb	2.70
		Polycentropodidae	*Polycentropus* Sp.	5	Filterer	cn	40.54
		Psychomyiidae	*Lype* Sp.	2	Scraper	cn	21.62
		Uenoidae	*Neophylax* Sp.	3	Scraper	cn	2.70
Insecta	Lepidoptera			6			2.70
		Pyralidae			Shredder	cb	5.41
Insecta	Coleoptera	Dytiscidae		5	Predator	sw, dv	8.11
			Agabus Sp.	5	Predator	sw, dv	5.41
			Deronectes Sp.	5	Predator	sw	2.70
			Hydroporus Sp.	5	Predator	sw, cb	16.22
		Elmidae	*Ancyronyx* Sp.	2	Scraper	cn, sp	18.92
			Dubiraphia Sp.	6	Scraper	cn, cb	27.03
			Macronychus Sp.	4	Scraper	cn	2.70
			Optioservus Sp.	4	Scraper	cn	2.70
			Oulimnius Sp.	2	Scraper	cn	5.41
			Stenelmis Sp.	6	Scraper	cn	5.41
		Gyrinidae	*Dineutus* Sp.	4	Predator	sw, dv	16.22
			Gyrinus Sp.	4	Predator	sw, dv	8.11
		Haliplidae	*Peltodytes* Sp.	5	Shredder	cb, cn	10.81
		Hydrophilidae	*Enochrus* Sp.	5	Collector	bu, sp	2.70
			Tropisternus Sp.	10	Collector	cb	2.70
		Ptilodactylidae	*Anchytarsus* Sp.	4	Shredder	cn	2.70

Table 3 (cont.). Tolerance Value (TV)[1], Functional Feeding Group (FFG), Habit, and Percent Occurrence of benthic macroinvertebrate taxa[2] collected at Maryland Biological Stream Survey sites in Wicomico County, 1994-1997. Abbreviations of habits are as follows: bu - burrower, cn - clinger, cb - climber, sp - sprawler, dv - diver, and sk - skater.

Class	Order	Family	Genus	TV	FFG	Habit	Percent Occurrence
Insecta	Diptera	Ceratopogonidae	*Alluaudomyia* Sp.		Predator	bu	2.70
			Bezzia Sp.	6	Predator	bu	2.70
			Culicoides Sp.	10	Predator	bu	2.70
			Helius Sp.	4	Predator	sp, bu	5.41
			Probezzia Sp.	6	Predator	bu	2.70
			Sphaeromias Sp.		Predator	bu	2.70
		Chironomidae	*Ablabesmyia* Sp.	8	Predator	sp	24.32
			Apsectrotanypus Sp.	5	Predator	bu, sp	5.41
			Brillia Sp.	5	Shredder	bu, sp	16.22
			Chironomus Sp.	10	Collector	bu	2.70
			Cladotanytarsus Sp.	7	Filterer	-	2.70
			Clinotanypus Sp.	8	Predator	bu	10.81
			Conchapelopia Sp.	6	Predator	sp	59.46
			Corynoneura Sp.	7	Collector	sp	16.22
			Cricotopus Sp.	7	Shredder	cn, bu	21.62
			Cricotopus/ Orthocladius Sp.		Shredder		48.65
			Cryptochironomus Sp.	8	Predator	sp, bu	2.70
			Dicrotendipes Sp.	10	Collector	bu	24.32
			Diplocladius Sp.	7	Collector	sp	2.70
			Endochironomus Sp.	10	Shredder	cn	13.51
			Eukiefferiella Sp.	8	Collector	sp	8.11
			Glyptotendipes Sp.	10	Filterer	bu, cn	2.70
			Heterotrissocladius Sp.		Collector	sp, bu	5.41
			Hydrobaenus Sp.	8	Scraper	sp	10.81
			Labrundinia Sp.	7	Predator	sp	5.41
			Limnophyes Sp.		Collector	sp	2.70
			Micropsectra Sp.	7	Collector	cb, sp	8.11
			Microtendipes Sp.	6	Filterer	cn	8.11
			Nanocladius Sp.	3	Collector	sp	8.11
			Nilotanypus Sp.	6	Predator	sp	2.70
			Orthocladiinae A Sp.		Collector		8.11
			Orthocladiinae B Sp.		Collector		2.70
			Orthocladius Sp.	6	Collector	sp, bu	8.11
			Paracladopelma Sp.	7	Collector	sp	2.70
			Parakiefferiella Sp.	4	Collector	sp	2.70
			Paralauterborniella Sp.	8	Collector	cn	2.70
			Paramerina Sp.	4	Predator	sp	2.70
			Parametriocnemus Sp.	5	Collector	sp	5.41
			Paratanytarsus Sp.	6	Collector	sp	24.32
			Paratrichocladius Sp.		Collector	sp	2.70
			Phaenopsectra Sp.	7	Collector	cn	27.03
			Polypedilum Sp.	6	Shredder	cb, cn	62.16
			Potthastia Sp.	2	Collector	sp	2.70
			Procladius Sp.	9	Predator	sp	18.92
			Prodiamesa Sp.	3	Collector	bu, sp	2.70
			Psectrocladius Sp.	8	Shredder	sp, bu	2.70

Table 3 (cont.). Tolerance Value (TV)[1], Functional Feeding Group (FFG), Habit, and Percent Occurrence of benthic macroinvertebrate taxa[2] collected at Maryland Biological Stream Survey sites in Wicomico County, 1994-1997. Abbreviations of habits are as follows: bu - burrower, cn - clinger, cb - climber, sp - sprawler, dv - diver, and sk - skater.

Class	Order	Family	Genus	TV	FFG	Habit	Percent Occurrence
			Rheocricotopus Sp.	6	Collector	sp	43.24
			Rheotanytarsus Sp.	6	Filterer	cn	40.54
			Stenochironomus Sp.	5	Shredder	bu	2.70
			Stictochironomus Sp.	9	Collector	bu	5.41
			Symposiocladius Sp.		Predator	sp	5.41
			Tanytarsus Sp.	6	Filterer	cb, cn	32.43
			Thienemanniella Sp.	6	Collector	sp	21.62
			Thienemannimyia Sp.		Predator	sp	8.11
			Tribelos Sp.	5	Collector	bu	10.81
			Trissopelopia Sp.		Predator	sp	2.70
			Tvetenia Sp.	5	Collector	sp	5.41
			ORTHOCLADIINAE		Collector		2.70
			TANYTARSINI		Collector		2.70
			Xylotopus Sp.	2	Shredder	bu	2.70
			Zavrelimyia Sp.	8	Predator	sp	13.51
		Empididae	*Chelifera* Sp.		Predator	sp, bu	5.41
			Hemerodromia Sp.	6	Predator	sp, bu	21.62
		Simuliidae		7	Filterer	cn	2.70
			Cnephia Sp.	4	Filterer	cn	8.11
			Prosimulium Sp.	7	Filterer	cn	16.22
			Simulium Sp.	7	Filterer	cn	37.84
			Stegopterna Sp.	7	Filterer	cn	45.95
		Tabanidae	*Chrysops* Sp.	7	Predator	sp, bu	2.70
		Tipulidae	*Dicranota* Sp.	4	Predator	sp, bu	2.70
			Hexatoma Sp.	4	Predator	bu, sp	2.70
			Pilaria Sp.	7	Predator	bu	2.70
			Pseudolimnophila Sp.	2	Predator	bu	5.41

1 Tolerance values are on a 0 (extremely sensitive) to 10 (tolerant) scale.
2 Taxa not identified to genus are presented in capital letters. Subfamily - Orthocladiinae; Tribe - Tanytarsini.
3 Nematomorpha is a phylum level identification. No further identification was made.

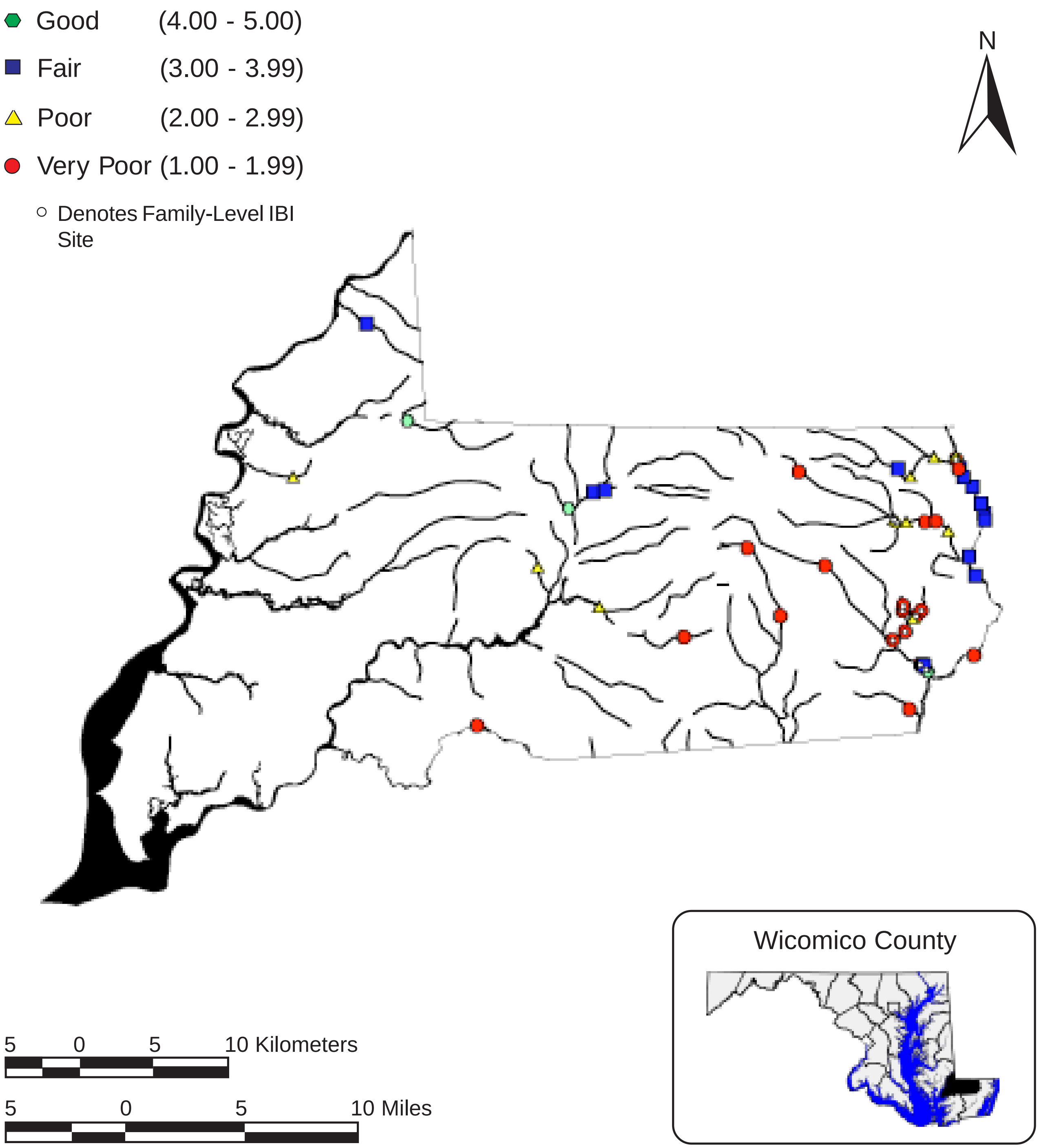

Figure 4. Stream ecological conditions based on the Benthic Macroinvertebrate Index of Biotic Integrity (B-IBI) at Maryland Biological Stream Survey sites in Wicomico County, 1994-1997.

Table 4. Percent occurrence of reptile and amphibian species collected at Maryland Biological Stream Survey sites in Wicomico County, 1994-1997.

Family	Common Name	Scientific Name	Number of Occurrences	Percent Occurrence
Bufonidae	Fowler's toad	*Bufo woodhousii fowleri*	3	7.69
Ranidae	bullfrog	*Rana catesbeiana*	22	56.41
	green frog	*Rana clamitans melanota*	28	71.79
	pickerel frog	*Rana palaustris*	2	5.13
	southern leopard frog	*Rana utricularia*	8	20.51
Chelydridae	common snapping turtle	*Chelydra serpentina*	5	12.82
Kinosternidae	common musk turtle	*Sternotherus odoratus*	4	10.26
Emydidae	eastern box turtle	*Terrapene c. carolina*	1	2.56
	eastern painted turtle	*Chrysemys p. picta*	8	20.51
	redbelly turtle	*Pseudemys rubriventris*	2	5.13
Colubridae	black rat snake	*Elaphe o. obsoleta*	1	2.56
	northern black racer	*Coluber c. constrictor*	1	2.56
	northern water snake	*Nerodia s. sipedon*	2	5.13
None			4	10.26

Table 5. Physical habitat data for Maryland Biological Stream Survey sites in Wicomico County, 1994-1997.

Site	Instream Habitat[1]	Epifaunal Substrate[1]	Velocity/Depth Diversity[1]	Pool Quality[1]	Riffle Quality[1]	Percent Embeddedness[1]	Percent Shading[1]	Maximum Depth (cm)[1]	Number of Woody Debris	Number of Rootwads	Percent Channel Flow[1]	Channel Alteration[1]	Bank Stability[1]	Riparian Width (m)[1]	Aesthetic Rating[1]
SO-S-005-109-95	5	1	7	3	13	100	20	24	0	0	100	5	6	10	7
WI-S-005-1-94	11	5	1	1	1	99	60	18	0		20	4	14	2	15
WI-S-016-211-95	5	3	6	13	0	100	10	87	0	0	90	4	14	4	8
WI-S-017-119-95	6	4	6	6	10	100	90	58	2	3	100	5	9	50	7
WI-S-019-208-97	14	10	10	10	11	100	30	34	0	0	50	8	15	10	11
WI-S-019-217-97	12	10	8	10	11	100	20	38	0	0	75	5	17	3	10
WI-S-023-112-95	16	13	10	9	13	60	85	51	8	7	90	15	17	40	16
WI-S-034-201-95	17	15	17	16	17	30	70	74	17	4	90	11	8	50	18
WI-S-037-210-97	5	3	6	11	11	100	10	70	2	0	100	5	16	0	11
WI-S-041-214-97	11	12	4	15	0	100	75	55	2	0	40	6	17	30	15
WI-S-054-1-94	15	14	9	10	11	99	50	46	0		90	9	7	11	16
WI-S-054-2-94	11	6	7	6	6	99	50	37	0		90	7	7	10	16
WI-S-055-303-97	11	10	8	16	16	100	65	200	2	0	95	5	10	50	11
WI-S-057-3-94	18	16	10	11	13	99	90	50	7		85	13	12	50	18
WI-S-057-309-97	15	14	10	14	10	100	75	67	7	3	85	10	15	50	15
WI-S-057-311-97	17	15	10	15	16	100	70	73	9	6	85	11	19	50	16
WI-S-057-319-97	19	18	10	16	16	100	70	79	13	5	90	11	15	50	16
WI-S-059-106-97	1	1	2	2	3	100	40	10	0	0	95	0	1	0	1
WI-S-063-220-95	16	10	17	14	16	100	60	125	4	1	75	9	16	50	16
WI-S-067-207-97	10	9	10	13	11	100	10	55	0	0	95	9	8	10	15
WI-S-067-219-97	10	6	11	15	16	100	20	79	1	0	95	5	11	0	11
WI-S-073-114-95	3	1	2	1	4	100	75	22	4	0	85	4	10	30	3
WI-S-074-103-97	10	5	12	10	13	100	25	54	0	0	90	2	13	30	15
WI-S-075-206-95	17	5	16	16	16	100	80	64	3	8	95	8	12	35	17
WI-S-082-113-95	6	11	7	7	8	100	80	32	11	2	70	5	13	50	7
WI-S-084-107-97	4	3	2	2	0	100	40	32	0	0	95	5	11	0	5
WI-S-085-102-95	5	1	3	7	0	100	50	35	5	3	99	4	15	50	11
WI-S-999-114-97	6	5	5	6	8	100	85	43	2	3	80	5	11	23	17
WO-S-003-306-97	14	14	6	11	11	100	60	61	5	7	95	7	10	5	17
WO-S-003-308-97	12	11	5	6	6	100	65	44	5	0	90	5	10	3	17
WO-S-003-312-97	9	11	8	11	13	100	80	110	4	4	98	11	15	50	15
WO-S-003-314-97	10	10	5	8	13	100	75	34	2	0	85	7	7	30	14
WO-S-003-320-97	12	11	5	9	11	100	70	44	7	5	97	8	11	50	12
WO-S-005-315-97	8	8	7	12	16	100	75	84	4	1	85	4	5	50	13
WO-S-008-1-94	8	4	5	7	0	99	85	57	3		90	3	11	50	11
WO-S-008-3-94	4	3	4	6	0	99	90	63	2		90	4	12	50	6

Table 5 (cont.). Physical habitat data for Maryland Biological Stream Survey sites in Wicomico County, 1994-1997.

Site	Instream Habitat[1]	Epifaunal Substrate[1]	Velocity/Depth Diversity[1]	Pool Quality[1]	Riffle Quality[1]	Percent Embeddedness[1]	Percent Shading[1]	Maximum Depth (cm)[1]	Number of Woody Debris	Number of Rootwads	Percent Channel Flow[1]	Channel Alteration[1]	Bank Stability[1]	Riparian Width (m)[1]	Aesthetic Rating[1]
WO-S-008-305-97	7	6	8	7	11	100	85	34	1	0	70	8	11	50	12
WO-S-019-318-97	14	12	10	14	16	100	80	117	8	3	90	5	5	50	16
WO-S-061-206-97	16	13	6	15	0	100	20	85	0	0	98	13	16	3	17

[1] MBSS Qualitative Habitat Metric - See Appendix B for Guidance

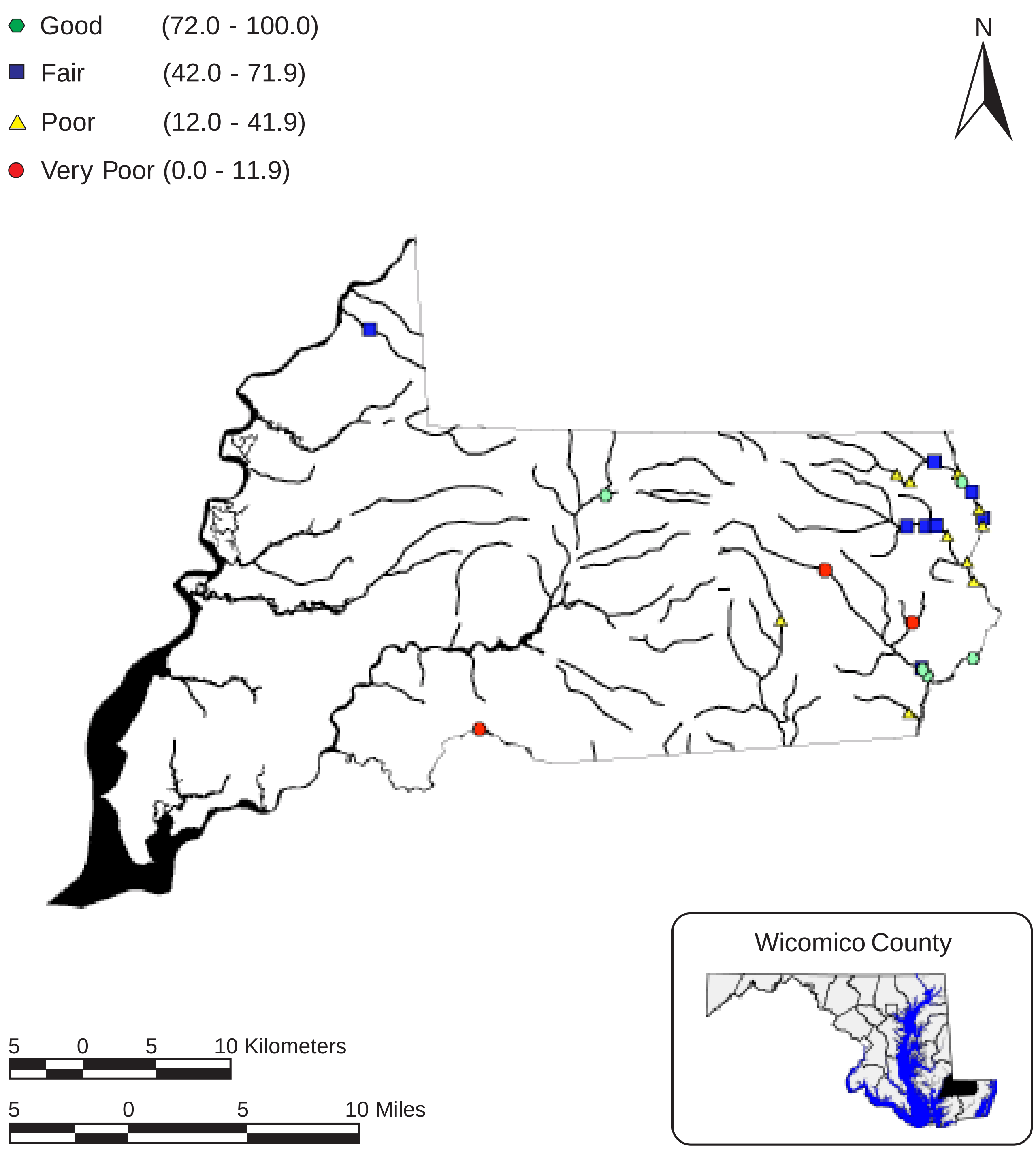

Figure 5. Stream ecological conditions based on the Physical Habitat Index (PHI) at Maryland Biological Stream Survey sites in Wicomico County, 1994-1997.

Table 6. Fish Index of Biotic Integrity (F-IBI), Benthic Macroinvertebrate Index of Biotic Integrity (B-IBI), Family-Level Benthic Macroinvertebrate Index of Biotic Integrity (Fam. IBI), and Physical Habitat Index (PHI) scores at Maryland Biological Stream Survey sites in Wicomico County, 1994-1997.

Site	Stream Name	F-IBI	B-IBI	Fam. IBI	PHI
SO-S-005-109-95	Passerdyke Creek	2.25	1.9		5.90
WI-S-005-1-94	Truitt Br			1.57	
WI-S-005-4-94	Truitt Br			1.29	
WI-S-016-211-95	South Prong Wicomico R	2.50	2.4		
WI-S-017-119-95	Walston Branch	2.25	1.6		
WI-S-019-208-97	South Fork Green Run	4.00	3.0		41.46
WI-S-019-217-97	Green Run	3.25	2.7		31.07
WI-S-023-112-95	Ut Nanticoke R	3.25	3.9		66.12
WI-S-034-201-95	Barren Creek	4.00	4.1		
WI-S-037-210-97	Burnt Mill Br	3.00	2.7		21.92
WI-S-041-202-97	Perdue Cr		1.9		
WI-S-041-214-97	Forest Grove Br	3.25	1.6		41.73
WI-S-054-1-94	Burnt Mill Br			2.14	
WI-S-054-2-94	Burnt Mill Br			2.43	
WI-S-055-303-97	Pocomoke R	3.00	1.3		83.12
WI-S-057-1-94	Adkins Race			2.71	
WI-S-057-3-94	Adkins Race			1.29	
WI-S-057-309-97	Adkins Race	4.00	3.0		68.78
WI-S-057-311-97	Adkins Race	4.50	4.1		77.59
WI-S-057-319-97	Adkins Race	4.25	3.6		83.73
WI-S-059-1-94	Truitt Br			1.57	
WI-S-059-106-97	Truitt Br	2.25	2.1		1.27
WI-S-059-2-94	Truitt Br			1.29	
WI-S-060-2-94	Truitt Br			1.00	
WI-S-060-3-94	Truitt Br			1.86	
WI-S-061-104-97	Burnt Mill Br		1.6		
WI-S-063-220-95	Leonard Pond Run	3.25	3.0		
WI-S-067-207-97	Burnt Mill Br	3.75	2.7		49.92
WI-S-067-219-97	Burnt Mill Br	3.75	1.6		59.18
WI-S-073-114-95	Owens Branch	3.25	2.7		
WI-S-074-103-97	Murray Br	3.75	1.9		46.89
WI-S-075-206-95	Leonard Pond Run	3.75	3.0		87.75
WI-S-082-113-95	Little Burnt Branch	3.25	4.4		
WI-S-084-107-97	Campbell Ditch	2.25	1.0		2.76
WI-S-085-102-95	Ut Nanticoke R	1.75	2.1		
WI-S-999-114-97	Duncan Ditch	2.75	1.6		14.33
WO-S-003-306-97	Pocomoke R	3.50	3.0		48.81
WO-S-003-308-97	Pocomoke R	2.75	3.6		24.67
WO-S-003-312-97	Pocomoke R	3.50	3.0		51.29
WO-S-003-314-97	Pocomoke R	3.25	3.9		19.91
WO-S-003-320-97	Pocomoke R	4.00	3.6		25.71
WO-S-005-315-97	Pocomoke R	3.00	3.9		38.81
WO-S-008-1-94	Pocomoke R			1.00	
WO-S-008-3-94	Pocomoke R				
WO-S-008-305-97	Pocomoke R	3.00	3.6		16.63
WO-S-019-318-97	Pocomoke R	3.00	3.0		78.34
WO-S-061-205-97	North Fork Green Run		1.9		
WO-S-061-206-97	North Fork Green Run	3.75	2.4		70.64

Table 7. Water chemistry data collected at Maryland Biological Stream Survey sites in Wicomico County, 1994-1997.

Site	pH	Conductivity (µS/cm)	Acid Neutralizing Capacity (µeq/L)	Nitrate (mg/L)	Sulfate (mg/L)	Dissolved Oxygen (mg/L)	Dissolved Organic Carbon (mg/L)
SO-S-005-109-95	6.64	0.185	453.41	1.984	25.011	7.00	8.00
WI-S-005-1-94							
WI-S-005-4-94	5.69	0.149	96.83	5.896	17.346		16.00
WI-S-016-211-95	6.44	0.109	262.27	2.825	7.239	6.40	5.00
WI-S-017-119-95	6.23	0.074	305.42	1.418	3.899	6.90	2.00
WI-S-019-208-97	6.49	0.150	232.90	4.522	14.572	7.80	11.70
WI-S-019-217-97	6.51	0.146	180.60	5.208	14.917	9.60	10.40
WI-S-023-112-95	6.23	0.076	90.79	0.520	13.186	7.00	8.00
WI-S-034-201-95	6.65	0.091	252.10	2.880	5.098	7.50	4.00
WI-S-037-210-97	6.28	0.147	252.60	4.526	15.264	9.00	11.10
WI-S-041-202-97	6.55	0.178	374.90	4.052	19.825		13.20
WI-S-041-214-97	6.48	0.118	211.90	1.405	12.535	1.00	14.60
WI-S-054-1-94	5.91	0.124	123.63	4.282	15.075		8.00
WI-S-054-2-94							
WI-S-055-303-97	6.20	0.124	206.70	2.872	14.324	6.40	11.70
WI-S-057-1-94	5.92	0.090	81.14	2.522	11.452		12.00
WI-S-057-3-94							
WI-S-057-309-97	6.32	0.109	173.10	2.276	10.791	5.80	13.40
WI-S-057-311-97	6.34	0.107	173.20	2.221	10.891	6.90	14.30
WI-S-057-319-97	6.55	0.106	261.50	1.479	9.557	6.80	15.80
WI-S-059-1-94	5.01	0.132	43.15	4.802	16.770		25.00
WI-S-059-106-97	5.98	0.152	202.10	4.820	17.289	6.90	25.60
WI-S-059-2-94							
WI-S-060-2-94	5.54	0.116	78.78	1.053	22.370		15.00
WI-S-060-3-94							
WI-S-061-104-97	5.98	0.103	78.90	3.048	14.244		10.00
WI-S-063-220-95	6.64	0.083	276.69	2.083	5.283	6.70	6.00
WI-S-067-207-97	6.30	0.144	223.30	4.054	14.736	7.80	9.10
WI-S-067-219-97	6.52	0.124	274.20	2.564	12.953	7.70	9.70
WI-S-073-114-95	6.72	0.154	409.07	5.686	6.143	6.30	4.00
WI-S-074-103-97	6.31	0.144	262.70	4.294	14.792	8.70	10.70
WI-S-075-206-95	6.67	0.079	263.10	1.428	4.717	5.70	6.00
WI-S-082-113-95	6.86	0.126	275.73	4.958	8.541	8.40	5.00
WI-S-084-107-97	4.57	0.045	-26.90	0.524	7.247	3.40	10.90
WI-S-085-102-95	4.99	0.121	17.51	1.045	28.600	4.00	10.00
WI-S-999-114-97	6.09	0.148	124.00	5.410	16.102	7.10	10.60
WO-S-003-306-97	6.00	0.118	128.60	3.360	13.035	5.90	12.90
WO-S-003-308-97	5.93	0.115	134.50	3.318	12.918	6.00	12.30
WO-S-003-312-97	6.12	0.112	169.20	2.652	11.840	5.70	11.60
WO-S-003-314-97	6.15	0.116	164.10	2.774	12.454	6.30	11.80
WO-S-003-320-97	6.29	0.105	186.10	2.090	11.564	5.50	13.30
WO-S-005-315-97	6.23	0.123	205.00	2.916	13.003	6.90	10.70
WO-S-008-1-94	5.76	0.086	110.20	1.826	10.960		13.00
WO-S-008-3-94							
WO-S-008-305-97	6.00	0.110	135.00	3.774	13.260	7.10	11.00
WO-S-019-318-97	6.24	0.104	178.60	2.094	11.319	6.00	13.50
WO-S-061-205-97	6.39	0.146	245.80	4.014	19.768		8.40
WO-S-061-206-97	6.38	0.143	231.70	4.730	15.019	7.90	8.10

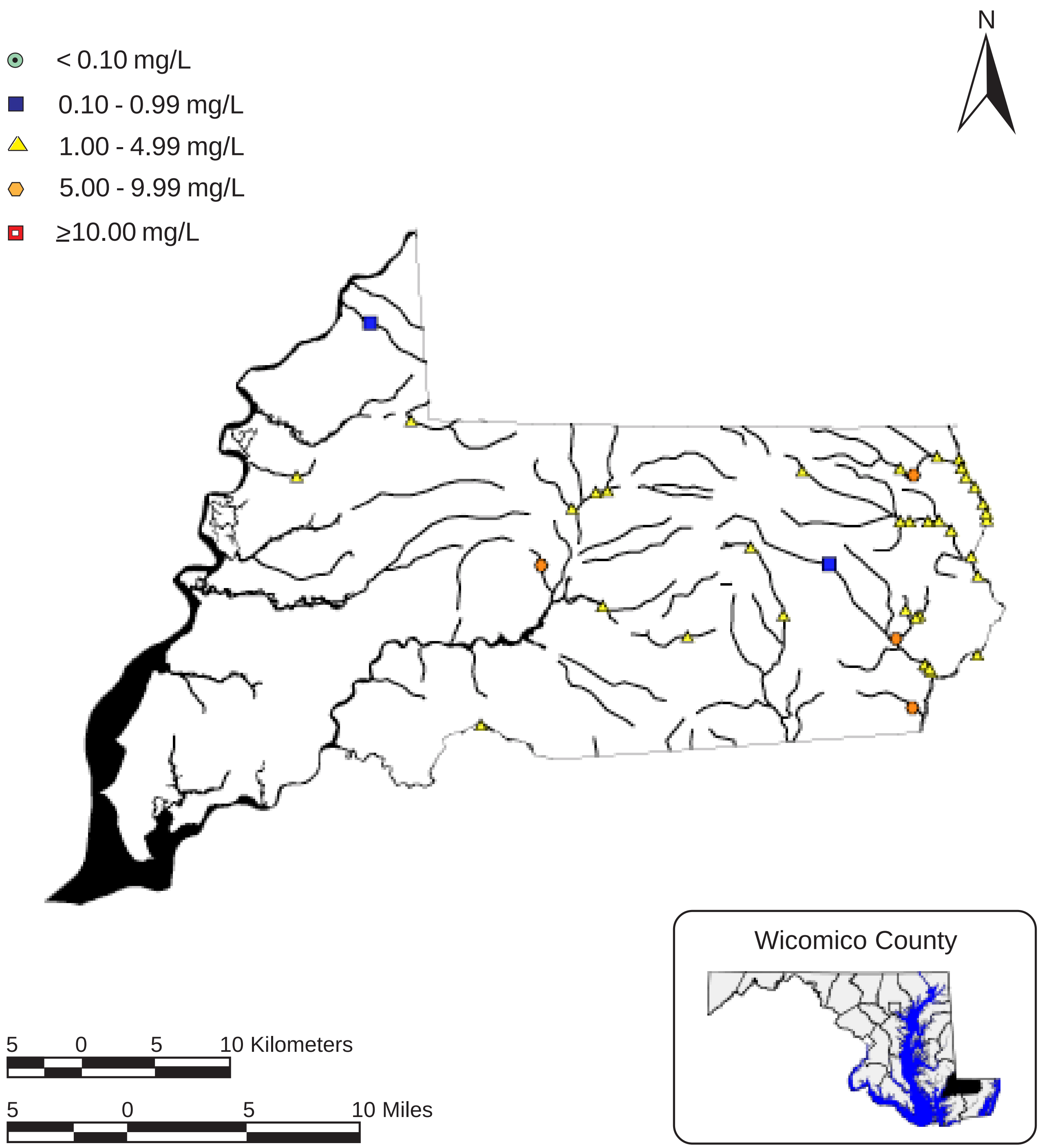

Figure 6. Nitrate-nitrogen concentrations (mg/L) at Maryland Biological Stream Survey sites in Wicomico County, 1994-1997.

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Appendix A. Summary of the types of data collected at Maryland Biological Stream Survey sites in Wicomico County, 1994-1997. Abbreviations used are as follows: F-IBI - Fish Index of Biotic Integrity; B-IBI Benthic Macroinvertebrate Index of Biotic Integrity; Fam.IBI - Family-Level Benthic Macroinvertebrate Index of Biotic Integrity; PHI - Physical Habitat Index.

Site	Stream Name	Fish	Benthic Macroinvertebrate	Herpetofauna	Habitat	Water Chemistry	F-IBI	B-IBI	Fam. IBI	PHI
SO-S-005-109-95	Passerdyke Creek	X	X	X	X	X	X	X		X
WI-S-005-1-94	Truitt Br	X	X	X	X				X	
WI-S-005-4-94	Truitt Br		X			X			X	
WI-S-016-211-95	South Prong Wicomico R	X	X	X	X	X	X	X		
WI-S-017-119-95	Walston Branch	X	X	X	X	X	X	X		
WI-S-019-208-97	South Fork Green Run	X	X	X	X	X	X	X		X
WI-S-019-217-97	Green Run	X	X	X	X	X	X	X		X
WI-S-023-112-95	Ut Nanticoke R	X	X	X	X	X	X	X		X
WI-S-034-201-95	Barren Creek	X	X	X	X	X	X	X		
WI-S-037-210-97	Burnt Mill Br	X	X	X	X	X	X	X		X
WI-S-041-202-97	Perdue Cr		X			X		X		
WI-S-041-214-97	Forest Grove Br	X	X	X	X	X	X	X		X
WI-S-054-1-94	Burnt Mill Br	X	X	X	X	X			X	
WI-S-054-2-94	Burnt Mill Br	X	X	X	X				X	
WI-S-055-303-97	Pocomoke R	X	X	X	X	X	X	X		X
WI-S-057-1-94	Adkins Race		X			X			X	
WI-S-057-3-94	Adkins Race	X	X	X	X				X	
WI-S-057-309-97	Adkins Race	X	X	X	X	X	X	X		X
WI-S-057-311-97	Adkins Race	X	X	X	X	X	X	X		X
WI-S-057-319-97	Adkins Race	X	X	X	X	X	X	X		X
WI-S-059-1-94	Truitt Br		X			X			X	
WI-S-059-106-97	Truitt Br	X	X	X	X	X	X	X		X
WI-S-059-2-94	Truitt Br		X						X	
WI-S-060-2-94	Truitt Br		X			X			X	
WI-S-060-3-94	Truitt Br		X						X	
WI-S-061-104-97	Burnt Mill Br		X			X		X		
WI-S-063-220-95	Leonard Pond Run	X	X	X	X	X	X	X		
WI-S-067-207-97	Burnt Mill Br	X	X	X	X	X	X	X		X
WI-S-067-219-97	Burnt Mill Br	X	X	X	X	X	X	X		X
WI-S-073-114-95	Owens Branch	X	X	X	X	X	X	X		
WI-S-074-103-97	Murray Br	X	X	X	X	X	X	X		X
WI-S-075-206-95	Leonard Pond Run	X	X	X	X	X	X	X		X
WI-S-082-113-95	Little Burnt Branch	X	X	X	X	X	X	X		
WI-S-084-107-97	Campbell Ditch	X	X	X	X	X	X	X		X
WI-S-085-102-95	Ut Nanticoke R	X	X	X	X	X	X	X		

Appendix A (cont.). Summary of the types of data collected at Maryland Biological Stream Survey sites in Wicomico County, 1994-1997. Abbreviations used are as follows: F-IBI - Fish Index of Biotic Integrity; B-IBI - Benthic Macroinvertebrate Index of Biotic Integrity; Fam. IBI - Family-Level Benthic Macroinvertebrate Index of Biotic Integrity; PHI - Physical Habitat Index.

Site	Stream Name	Fish	Benthic Macroinvertebrate	Herpetofauna	Habitat	Water Chemistry	F-IBI	B-IBI	Fam. IBI	PHI
WI-S-999-114-97	Duncan Ditch	X	X	X	X	X	X	X		X
WO-S-003-306-97	Pocomoke R	X	X	X	X	X	X	X		X
WO-S-003-308-97	Pocomoke R	X	X	X	X	X	X	X		X
WO-S-003-312-97	Pocomoke R	X	X	X	X	X	X	X		X
WO-S-003-314-97	Pocomoke R	X	X	X	X	X	X	X		X
WO-S-003-320-97	Pocomoke R	X	X	X	X	X	X	X		X
WO-S-005-315-97	Pocomoke R	X	X	X	X	X	X	X		X
WO-S-008-1-94	Pocomoke R	X	X	X	X	X			X	
WO-S-008-3-94	Pocomoke R	X	X	X	X					
WO-S-008-305-97	Pocomoke R	X	X	X	X	X	X	X		X
WO-S-019-318-97	Pocomoke R	X	X	X	X	X	X	X		X
WO-S-061-205-97	North Fork Green Run		X			X		X		
WO-S-061-206-97	North Fork Green Run	X	X	X	X	X	X	X		X

Appendix B. Physical habitat condition measured by the Maryland Biological Stream Survey, 1994-1997. All variables rated on a scale of 0 (poor) to 20 (optimal) unless otherwise noted.

SUBSTRATE AND INSTREAM COVER

Instream Habitat is rated according to the perceived value of habitat to the fish community. Higher scores are assigned to sites with a variety of habitat types and particle sizes. In addition, higher scores are assigned to sites with a high degree of uneven substrate, including logs and rootwads. In streams where substrate types are favorable but flows are so low that fish are essentially precluded from using the habitat, low scores are assigned. If none of the habitat within a segment is useable by fish, a score of zero is assigned.

Epifaunal Substrate is rated based on the amount and variety of hard, stable substrates usable by benthic macroinvertebrates. Because they inhibit colonization, flocculent materials or fine sediments surrounding otherwise good substrates are assigned low scores. Scores are also reduced when substrates are less stable.

Velocity/Depth Diversity is rated based on the variety of velocity/depth regimes present at a site (slow-shallow, slow-deep, fast-shallow, and fast-deep). As with embeddedness, this metric varies by stream gradient.

Pool/Glide/Eddy Quality is rated based on the variety and spatial complexity of slow or still water habitat within the sample segment. In high-gradient streams, functionally important slow water habitat may exist in the form of larger eddies. Within a category, higher scores are assigned to segments which have undercut banks, woody debris or other types of cover for fish.

Riffle/Run Quality is based on the depth, complexity, and functional importance of riffle/run habitat in the segment, with highest scores assigned to segments dominated by deeper riffle/run areas, stable substrates, and a variety of current velocities.

Embeddedness is a percentage of surface area of larger particles that is surrounded by fine sediments on the stream bottom. In low gradient streams, embeddedness may be high even in relatively unimpaired watersheds.

CHANNEL CHARACTER

Channel Alteration is a measure of large-scale changes in the shape of the stream channel. Channel alteration includes: concrete channels, artificial embankments, obvious straightening of the natural channel, rip-rap, or other structures, as well as recent bar development. Ratings for this metric are based on the presence of artificial structures as well as the existence, extent, and coarseness of point bars, side bars, and mid-channel bars which indicate the degree of flow fluctuations and substrate stability. Evidence of channelization may sometimes be seen in the form of berms that parallel the stream channel.

Bank Stability is rated based on the presence/absence of riparian vegetation and other stabilizing bank materials such as boulders and rootwads, and frequency/size of erosional areas. Sites with steep slopes are not penalized if banks are composed solely of stable materials.

Channel Flow Status is the percentage of the stream channel that has water, with subtractions made for exposed substrates and dewatered areas.

RIPARIAN CORRIDOR

Shading is rated based on estimates of the degree and duration of shading at a site during summer, including any effects of shading caused by land forms.

Appendix B (cont.). Physical habitat condition measured by the Maryland Biological Stream Survey, 1994-1997. All variables rated on a scale of 0 (poor) to 20 (optimal) unless otherwise noted.

<u>**Riparian Buffer**</u> is rated according to the size and type of the vegetated riparian buffer zone at the site. Cultivated fields for agriculture that have bare soil to any extent are not considered as riparian buffers. At sites where the buffer width is variable, or direct delivery of storm runoff or sediment to the stream is evident or highly likely, the narrowest representative buffer width in the segment (e.g., 0 if parking lot runoff enters directly to the stream) is measured and recorded even though some of the stream segment may have a well developed riparian buffer.

AESTHETICS/REMOTENESS

<u>**Aesthetics**</u> are rated according to the visual appeal of the site and presence/absence of human refuse, with highest scores assigned to stream segments with no human refuse and visually outstanding character.

<u>**Remoteness**</u> is rated based on the absence of detectable human activity and difficulty in accessing the segment.